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REGULAR PAPER

Spectral ecologies: De/extinction in the Pyrenees

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Abstract

How is extinction problematised through biotechnological and ecological interventions, and how might such mediations elucidate different understandings of biotic loss and recovery? The bucardo – an endemic ibex from the Pyrenees – is the only extinct animal to have ever been cloned, and for seven short minutes in 2003, "extinction was not forever." Using the bucardo's extinction as a starting point, rather than an ending, this paper addresses the "spectral ecologies" of the Pyrenees. Drawing on interviews and extensive ethnographic work conducted in Spain and France, I discuss the implications of this cloning project, and examine the various ways in which it is contested. Speculative futures of bucardo clones "returning" to the Pyrenees seem unlikely, however, following the successful introductions of another subspecies of ibex to the French Pyrenees in 2014. Such events – following the mobilities and geographies of the ibex themselves – invalidate justifications for cloning in conservation. Spectral ecologies are characterised through the unsettling of – and departures from – linear temporalities. I broaden the ontological scope of species resurrection to attend to phenotypic shifts associated with ecological restoration projects, which I call "de/extinction." De/extinction unsettles a range of epistemological assumptions concerning two of conservation's key concepts: species and extinction. Introduced ibex in the Pyrenees are beginning to resemble the defining features of bucardo with every new generation, a fascinating reworking of the bucardo's absence. The figure of the ghost brings to the fore multiple pasts and futures, human and nonhuman, materialising and affecting bodies in spectral ecologies. This case offers a theoretical advance to the field of extinction studies and cultural geographies in considering different meanings of "the end," and the imagined futures of "lost" biota.

KEYWORDS

bucardo, cloning, de/extinction, de-extinction, ecological restoration, the Pyrenees

1 | IN THE FOOTSTEPS OF GHOSTS

This is a paper about the bucardo, an ibex endemic to the Pyrenees, and the interventions of various humans, nonhumans, and technologies that continue to shape the ways it is understood. For centuries the bucardo was stuff of ghost stories; spoken of, but not seen, present in its absence, absent in its presence. Days after the beginning of the 21st century, the last living bucardo – known by many internationally as Celia – was crushed to death by a falling fir tree in the Spanish Pyrenees. Yet the bucardo continue to haunt. Gone, but not gone. Before Celia died, she was trapped and tranquillised by a team of scientists from Zaragoza, Aragón. They took clippings of her ear; soon after her fibroblast skin cells were cryopreserved and stored in multiple locations. Three years after Celia's death, the bucardo became the first extinct taxon to have been "brought back to life" when a clone was born to a surrogate mother in a laboratory (Folch et al., 2009). The cloned kid died after seven minutes. But for seven minutes, extinction was a malleable ontology, challenged through an assemblage of technologies and epistemic practices. Prominent synthetic biologist George Church and co-author Ed Regis described this as a "turning point in the history of biology," on the basis that, following the birth, "extinction was no longer forever" (2012, p. 136). Life's settings had changed, and these settings had markedly altered biocultural significance.

In the Vallée d'Aspe one dawn in August 2019, morning was slowly bringing warmth to the French Pyrenees and rays of sunlight were finding their way into the depths of the valley. A crowd of people had gathered; they waited, mostly silent, with a subtle yet palpable buzz of excitement punctuating the air. Three zoological transport boxes were grouped together in the clearing (Figure 1). Inside them were Iberian ibex, which had been brought overnight from the Sierra de Guadamarra, not far from Madrid. They weren't bucardo – they weren't the endemic animal to the Pyrenees but a different subspecies – yet there are very few people who'd be able to readily distinguish them by sight alone. Their horns were faintly smaller, they were less thickset: the morphologies of ibex accustomed to warmer climatic conditions. As the crowd of attentive bystanders waited, an ecologist invited the crowd to envision a Pyrenees populated once more with ibex. For the restoration project, it didn't matter where these ibex were from, rather where they were going. From the valley's vantage point, silhouettes appeared on the horizon,

FIGURE 1 Iberian ibex in zoological transport boxes near the town of Accous in the Vallée d'Aspe, Parc National des Pyrénées, France
Source: Photograph taken by the author in August 2019

which could hardly be deciphered with the naked eye. Binoculars were enthusiastically circulated among acquaintances, with all people trying desperately to capture a glimpse, an encounter. A group of ibex were welcoming their new arrivals. Within seconds they were gone; once again, the stuff of ghost stories. Familiar but not quite the same; uncanny. Celia's ghosts were appearing in different ways.

Bucardo were hunted to extinction (Acevedo & Cassinello, 2009; Crampe, 2020; García-González & Herrero, 1999; García-González & Margalida, 2014; Woutersen, 2000, 2012). They were considered one of Europe's most important trophy animals by the 19th century, valued above all for their horns, attracting recreational hunters from France and Britain in search of an animal that was infamously ghostly and difficult to encounter (Searle, 2021). By the early 20th century, hunting pressures had reduced the bucardo's range to its last refuge in the Ordesa valley, nestled in the high altitudes of the Spanish Pyrenees, a stone's throw from the French border (Cabrera, 1911, 1914). In 1918, the Ordesa y Monte Perdido national park was founded to protect what remained of the bucardo's habitat, however the population had been subjected to severe genetic bottlenecking and Ordesa did not provide ample opportunity for grazing. Sergio, an ecologist who had worked in Ordesa, reflected that conservationists "were always in the footsteps of ghosts."

Cloning scientists claimed that their overall objective was the repopulation of the Pyrenees.[1] It was the first and only "de-extinction" project to utilise interspecific nuclear transfer cloning as a method (Adams, 2017; Novak, 2018; Sandler, 2017; Searle, 2020; Sherkow & Greely, 2013). These scientists believed cloning to be the only means of filling the ecological absence left in the wake of the bucardo's extinction (*Capra pyrenaica pyrenaica*). Yet this claim was shaken in 2014, when another subspecies of ibex (*Capra pyrenaica victoriae*) was translocated to the French Pyrenees, close to Ordesa. Further release efforts followed, winning a considerable amount of public and media engagement in both Spain and France. Iberian ibex are becoming an established aspect of the Pyrenean landscape, in the footsteps of the bucardo's ghosts. This paper examines both of these interventions, asking how they contribute to new understandings of extinction in the Anthropocene. I draw them into conversation with spectral geographies in order to theorise "spectral ecologies,"[2] understood as the biological and cultural – biocultural – afterlives of extinction.

The bucardo was a ghost animal (McCorristine & Adams, 2020) – on the brink of disappearance – for decades preceding its extinction. I take its extinction as a beginning, rather than an ending, and build on extensive research with those actively engaging the bucardo's absence in a variety of forms. Between April 2018 and March 2020, I conducted ethnographic research in the Pyrenees and the surrounding cities from which certain organisations are headquartered (Figure 2). This involved semi-structured interviews and participant observation with ecologists, environmental activists, hunters, and cloning scientists, who have remained anonymous. Ecologists I spoke to generally worked, or had worked, in the two national parks in the central Pyrenees: *Parc National des Pyrénées* (France) and *Parque Nacional de Ordesa y Monte Perdido* (Spain). The team of scientists responsible for the bucardo's cloning in 2003 was composed of researchers based at the *Centro de Investigación y Tecnología Agroalimentaria de Aragón* [CITA, the Aragonese Centre for Agrotechnological Research, a regional government institute] and external collaborators mostly linked to the French *Institut National de la Recherche Agronomique* [INRA, the National Institute for Agricultural Research, a public institution that disbanded in 2020]. Many participants had since retired or changed institutions since the early 2000s.

I conducted interviews in Spanish and French, and later translated them into English; as such, the material presented below reflects an "inadequate and incomplete translation" of how research participants "feel, think, and act" about the bucardo (Govindrajan, 2018, p. 26). The aforementioned ethnographic vignette of an ibex translocation is one example of an effort to grasp public moods and atmospheres concerning ecological restoration (Airas, 2019; Anderson, 2009; Lorimer et al., 2019). Interviews with cloning scientists and activists, in particular, relied on participants' reflection to the time before the initial release of Iberian ibex to the Pyrenees in 2014. Oral histories from these interviews are therefore co-produced – what Mark Boyle (2009) calls "co-authoring memories" – and my account reflects such partialities.

In this paper I propose that de-speculating de-extinction away from what Ronald Sandler (2013, 2014) calls "technological wizardry," or "making it mundane" (Friese & Marris, 2014), holds promise for imagining alternatives beyond the "Promethean dreams" of a technological fix (Minteer, 2018). Normatively, de-extinction is considered in three broad forms of bringing aspects of extinct biota back: cloning, back-breeding, and genetic engineering (Corlett, 2017; Fletcher, 2020; Jørgensen, 2013; Preston, 2017; Seddon, Griffiths et al., 2014; Seddon & King, 2019; Seddon, Moehrenschlager, & Ewen, 2014; Sherkow & Greely, 2013; Thiele, 2020). These techniques rely on the creation of organisms that resemble extinct biota; whether these animals are authentic proxies for absent ecologies is a matter of intense philosophical and scientific debate (Campbell, 2017; Novak, 2018; Siipi, 2014; Siipi & Finkelman, 2017). Rather, considering more-than-human agencies as challenges to the firm binary between extinct and extant sheds light on the liminal space between the binary: "de/extinction" (Searle, 2020). In the next section, I attend to the ontological and epistemological implications of de/extinction in the broad sense. I then delve into the empirical material of the bucardo's afterlives, and outline the different ways in which Pyrenean ecologies are haunted by the

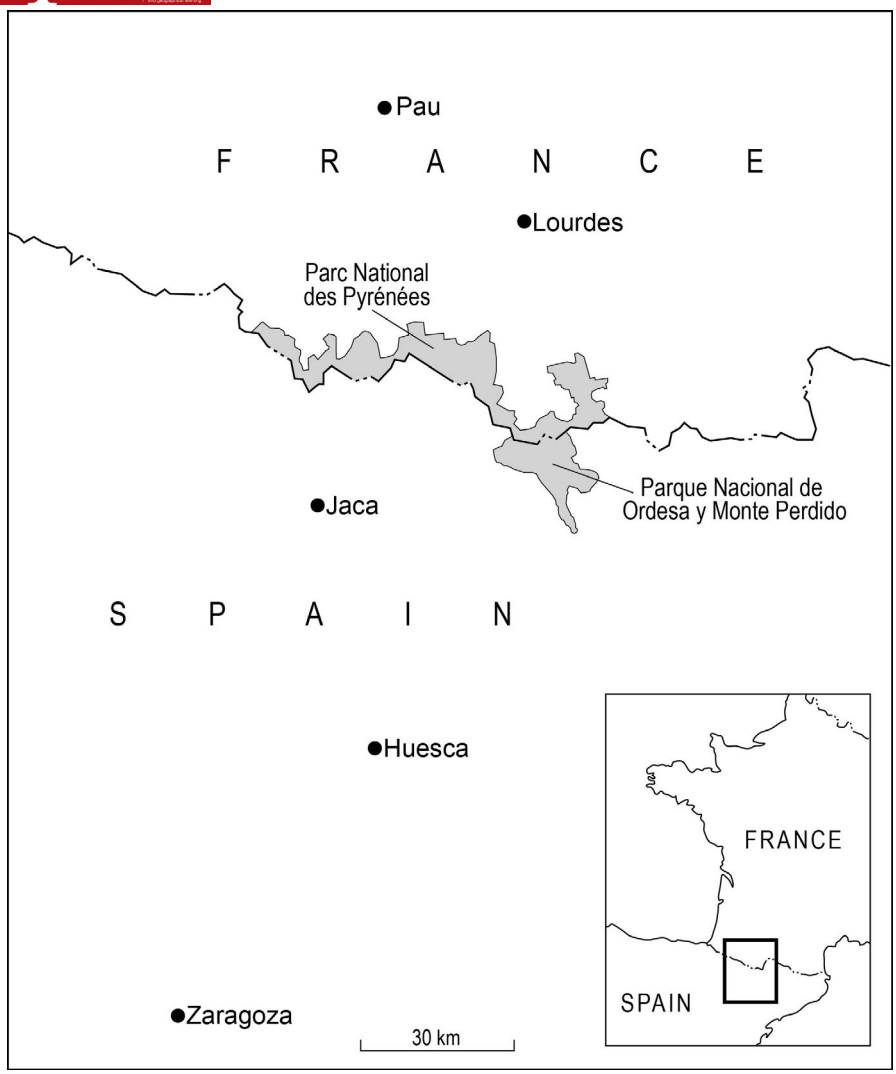

FIGURE 2 Simplified map of primary research locations during this research project. Other sites not shown include Madrid, Barcelona, Tarbes, and Paris

animal's absent presence. Although fundamentally a site-specific and unique case, I posit that the bucardo's story sheds light on the changing meanings of biotechnologies, species loss, and biotic recovery. This case offers a theoretical advance to the field of extinction studies and spectral geographies in its attention to different meanings of "the end," and the imagined futures of biota considered to be "lost."[3]

2 | SPECTRAL GEOGRAPHIES OF DE/EXTINCTION

Spectres offer a fruitful way of thinking through the contemporary extinction crisis, whereby the ghost acts as an agential metaphor for reckoning with biotic loss (McCorristine & Adams, 2020), in addition to emerging as the analytical focus of research. What might it mean to meddle with the discrete certainties of extinction, by *bringing something back*? The revenant returns from the past, but arrives in the present, and therefore cannot wholly belong to either time. As Jacques Derrida sets out in *Spectres of Marx*, "repetition *and* first time, this is perhaps the question of the event as question of the ghost" (1993, p. 31). Bringing something back is a departure from temporal linearity, it is an active engagement with multiple pasts and multiple futures, it is anachronistic. As such, a hauntology – Derrida's portmanteau for ontology and haunting,[4] considerations of the ghostly – not only speaks to the losses and absences of ecology, but also accounts for the making-present of events in their wake.

The figure of the ghost has found a new prominence in our understandings of the contemporary extinction crisis (Barrow, 2009; Bersaglio & Margulies, 2021; van Dooren, 2014, 2017; Gan et al., 2017). Juno Salazar Parreñas (2018) notes that

extinction is a shared experience sensed in a multitude of timescales: i) the affective, instantaneous and precognitive, embodied and felt in bodies that span different timeframes; ii) the *longue durée*, spanning centuries, of anthropogenic impacts on the environment directly caused by colonialism and industrialisation; and iii) the epochal deep time of evolution. To consider the ghosts of de/extinction's pasts and futures – and their agential forces in the co-fabrication of our politics, places, and perceptions – is to consider the ghosts of ecological relations across spatial and temporal scales.

Extinction is a gradual, quotidian, unfurling process (van Dooren, 2019; Wrigley, in press). It haunts – between presence/absence and past/present – and is a "non-linear and paradoxical process in that it leaves traces, signs and clues, and can provoke recurring reappearance" (McCorristine & Adams, 2020, p. 105). McCorristine and Adams illustrate that not only do hauntings of past extinctions have palpable and material consequences for the practices of conservation, they also present de-extinction as a "critical context for further debates about how absence and presence perform work in conservation and how cultural geographers might deal with the language and practice of 'bringing back the dead' in a more-than-human world" (2020, p. 111). Recently, more-than-human spectrality has garnered considerable attention in the cultural geographies of biotic loss and recovery (Bastian, 2020; Bersaglio & Margulies, 2021; Fredriksen, 2021; Garlick, 2019; Jørgensen, 2016; Lorimer, 2020; Searle, 2020, 2021; Symons & Garlick, 2020; Toso et al., 2020; Wrigley, 2020). For Ben Garlick and Kate Symons, "geographies after extinction are haunted geographies" (2020, p. 132) that provoke new affective activities, relations, and attachments (Garlick, 2019).

Geographers have been interested in spectres for some time (Coddington, 2011; Degan & Hetherington, 2001; Edensor, 2001, 2005; Frers, 2013; Holloway & Kneale, 2008; McCormack, 2010; Meier et al., 2013; Wylie, 2005, 2007, 2009). In spectral geographies, "haunting is not a value-neutral term: it highlights histories that cannot rest" (Coddington, 2011, p. 748). Histories that cannot rest require our attunement to them, our embodiment of spectres, and alternative forms of writing and representation that seek to break from geographical traditions that privilege presence. Ghostly assemblages are generative of new intimacies between distant bodies and events from both the past and the future, unsettling the present (Maddern & Adey, 2008). Attuning to haunting challenges notions of linear time in our experience of space and place, teasing out the tensions between then and now, acting in-between to "supplement and disturb" (Wylie, 2005). Even when coming from the same past, ghosts affect us in the present, generative of new meanings and new forms of unsettling history. Experiencing ghostly presences requires our attunement and embodiment of them, and can never, therefore, be uniform. Ghosts multiply rather than rationalise, as continuing legacies of the past continue to be contested by those in the present, as exemplified in postcolonial sites (Busbridge, 2015; Coddington, 2011).

Ghosts come to be known through their inference on matter and bodies rather than direct contact (McCormack, 2010). For Derek McCormack, sensing spectres can be active or passive – incurring through affecting or being affected – an ongoing oscillation encompassing bodies of different degrees "of affective intensity and duration" (2010, p. 633). This treatment of affect as a defining feature of spectral sensing opens up to irrationality and impulse, and the felt intensities and atmospheres of ordinary life (Anderson, 2009; Lorimer et al., 2019). To consider affects of spectrality does not involve distinguishing between the traces of human and nonhuman bodies. What is more important is their shared capacity to produce affects (McCormack, 2010). And even if it is the actions of certain humans conjuring these ghosts, the bodies and histories that are animated can be human, nonhuman, living, nonliving – all these entities *write* particular *traces* on the world, which persist, affect, and are affected in different ways.

I use the term de/extinction with a slash to signal the performative and liminal qualities of the ontological contact zone between extinct and extant, life and death, populated with ghosts of the past and future. For Karan Barad (2010, 2012), the slash invites an active rethinking of the binary and a destabilisation of prefixes (Juelskjær et al., 2012; Radomska, 2017), which reflects the potential of liminality to unsettle previously held epistemological assumptions (McConnell, 2017). De/extinction is a proactive and interactive questioning of the extinction concept and altered sensibilities to its presences and absences. Ben Novak problematises consensus on de/extinction in a 2018 paper published in the journal *Genes*, noting that issues are found in the definitional discrepancies of "species" and "extinction," both of which "have always been hugely complex biological and philosophical concepts" (2018, p. 2). Novak contends that the advent of cloning and genetic engineering technologies and their social imaginary is a foregrounding of age-old existential questions in biology, in that "biotechnology changes the concept of extinction" (2018, p. 8); yet he also states that reintroductions of locally extinct animals do the same, a point echoed by others who foreground the importance of *trait* restoration rather than those shaped by the boundaries drawn around species that dominate conservation (Corlett, 2016; Jørgensen, 2013; Seddon, Griffiths et al., 2014; Shapiro, 2015). I will argue below that the slow, adaptive processes of adaptation that fill the absent niches and habitats left by extinction are, in a way, reanimating the dead in the Pyrenees.

Recovering lost biota is an emotional process involving mourning and hope, and various approaches to ecological restoration can be considered material engagements with this process (Cunsolo & Landman, 2017; van Dooren & Rose, 2017; Heise,

2016; Jørgensen, 2019; McCorristine & Adams, 2020; Searle, 2020). Intermediations in loss and recovery occupy uncanny temporalities; references to the past through intervention for the future – hauntings. For Dolly Jørgensen, it is "the feeling of environmental lost-ness and the potential found-ness that motivates decisions about recovering locally extinct animals" (2019, p. 2). The original proposal to introduce Iberian ibex to France was formalised in 1990, founded on "ethical, scientific, aesthetic, and economic" rationales – all of which draw on the idea that something was *missing* without ibex in the Pyrenees (Crampe, 1990). As I will discuss in what follows, the notion that translocated Iberian ibex *belong* in the Pyrenees is also deeply contested by a range of actors.

In the bucardo's de/extinction, moreover, ghosts of a lost future shape the practices of conservation in the present – a disjunction shaped by emotional attachments to a longed-for past (Fisher, 2014). Both repetition and first time, both *revenant* and *arrivant*, the ghost is multiple from the outset owing to this temporal disjunction: returning from the past yet arriving fresh and anew in the present. The spectre always both at once, flowing between them, "one cannot control its comings and goings because it *begins by coming back*" (Derrida, 1993, p. 32). For Derrida, the space "between life and death" and "between all the 'two's' one likes" is "ethics itself" (1993, p. 14). This is because considerations of this binary foster responsibility and respect for justice concerning "those who *aren't there*, of those who aren't there any longer, or those who aren't *yet present and living*" (1993, p. 16). In what follows, I turn to the spectral ecologies of the Pyrenees. First, I examine the bucardo's failed cloning attempt, and consider its contestation and contemporary political significance. Second, I explore the restoration project in the French Pyrenees and tease out the geopolitics of transborder translocations. Third, I consider the more-than-human agencies at play the bucardo's de/extinction story, which enables considerations and critiques of cloning as a restorative practice. I bring these interventions together to theorise spectral ecologies: conjuring new worlds, and new afterlives, in response to extinction.

3 | CLONING AND ITS CONTESTATIONS

The bucardo was on the brink of extinction by the time conservation concern emerged at the beginning of the 20th century. Although its hunting was prohibited in 1913, and the Ordesa national park founded in 1918 to protect its habitat (Cabrera, 1911, 1914; de las Cuevas, 1920), conservation efforts were halted by the Spanish Civil War (1936–1939) and subsequent socio-economic consequences of the Francoist fascist dictatorship (García-González & Herrero, 1999; Woutersen, 2012, 2019). Following Spain's transition to democracy in the 1970s and later ascension to the European Union in 1986, an action plan to rescue the remnant population from extinction was initiated (Eiroa García & Urbieta Gale, 1993; Fernández-Arias et al., 1997). Funding was secured by the EU's LIFE transborder project for endemic Pyrenean vertebrates.[5] However, to the ecologists' dismay, the first extensive bucardo survey concluded that in 1995 only three females remained in Ordesa (Crampe, 2020). Conservationists would have to hybridise with other ibex in order to "save the bucardo's genetic diversity," according to Sergio, who was working in Ordesa at the time.

In January 1996, ecologists caught one of the remaining bucardo by cage-trapping in Ordesa. She was kept in captivity with Iberian ibex males in an effort to stimulate crossbreeding, yet after ten months in captivity, the bucardo died due to a range of illnesses associated with captivity and inbreeding without being able to reproduce. Soon there was just one bucardo left. In his Zaragoza office, I met with Carlos, who works in biodiversity management for the Aragón government. He recounted that after a tiresome struggle to reach political consensus between governmental actors, two fertile Iberian ibex males were released by helicopter in December 1996. They wore radio-tracking collars, and within a month they joined with the last bucardo female in Ordesa, where they spent nearly a year together. Hybridisation was unsuccessful, which for Carlos demonstrated the poor suitability of Iberian ibex to the Pyrenean winter, and the introduced individuals died. The introduced ibex did die, although one of them in fact lived for at least 13 years in the region surrounding Ordesa, a male nicknamed Correcaminos [road runner] by the park guards due to the long distances it would cover (Gobierno de Aragón, 2019). Gaël, an ecologist working across the French Pyrenees, told me that "Correcaminos' survival was a magnificent demonstration of the adaptability of the Iberian ibex to the Pyrenean climate." This was a direct contradiction of Carlos's account, showing how conflicting narratives are used to support varying ideological positions on Pyrenean conservation, to which Gaël commented: "many said the failure was that they didn't cross-breed, but for us their survival showed that they could adapt." Jean-Paul Crampe, a leading figure in the restoration project, notes that Correcaminos is conveniently stricken from many accounts as his survival complicates the narrative that only endemic bucardo were fit for the Pyrenean habitat (Crampe, 2020).

For cloning scientists and geneticists in Zaragoza, the failure of Iberian ibex to hybridise with bucardo was a catalytic impetus to purse a biotechnological fix in the form of a biopsy, cryopreservation, and cloning. The bucardo's extinction in Ordesa was, for a certain subset of this scientific community, a provocation to explore the technological novelties promised by the possibilities (reminiscent of science-fiction) of bringing extinct taxa back to life through cloning. For ecologists in the French

Pyrenees, the adaptation of one translocated ibex to the Pyrenees was a glimmer of hope, a sign that further translocations could potentially populate the Pyrenean massif with another subspecies of *Capra pyrenaica*. Such partial interpretations elucidate the ways in which particular interest groups construct frames within which to justify interventions in the bucardo's de/extinction, whether they be in a laboratory, shaped by interests in the genome and aspirations for experimental advancement, or in the Pyrenees, shaped by interests in landscape-scale conservation and aspirations for restoration.

Felipe, one of the cloning scientists in Zaragoza, told me that both *in situ* and captive hybridisation failures meant that scientists "had to go to the last resort … and the last resort was cloning." Carlos added: "we needed to trap Celia and let her go right away. But we had to trap her to preserve her genome." The last bucardo – Celia – was successfully trapped on 20 April 1999, tranquillised, and her genetic material cryogenically preserved. When Celia died in Ordesa, the bucardo became the first extinct taxon to be outlived by their own intact cells (Searle, 2020). Such achronological injunctions – departures from the linearities of evolutionary time – are likely to become more commonplace with the onset of speculative cryo-conservation (Chrulew, 2017; Keck, 2017; Ryder et al., 2020; Wrigley, in press). Celia's extracted cells took on novel experimental meanings in the specific epistemic context of the laboratory (Gieryn, 2006; Greenhough, 2006, 2011; Kohler, 2002).

Cloning scientists and geneticists were intent on retaining the bucardo's genetic purity via somatic cell nuclear transfer, yet this procedure was ironically dependent on an assemblage of chimeras (Friese, 2010). Hybrid domestic-wild ibex were purposely reared by crossbreeding Iberian ibex with domestic goats, facilitating longer gestation periods suitable for the development of a "bucardo" embryo, while also enabling captive pregnancies due to surrogate docility. These surrogate mothers, and the everyday relationships between scientists and animals, are often excluded from accounts of the bucardo cloning, which favour the headline-grabbing cloning attempt of an extinct subspecies. Attending to these practices, and writing them into accounts of de/extinction, elucidates the toll exerted on experimental animals and considerations of its ethical implications (Greenhough & Roe, 2011, 2019). "Bucardo" embryos were prepared by enucleating oocytes from domestic goats and reconstructing the cells with the preserved genetic material from Celia's biopsy, which were then transferred to a total of 57 surrogate mothers (Folch et al., 2009). Most pregnancies miscarried, but one carried to full term. A bucardo clone was delivered via Caesarean section on 30 July 2003, and died seven minutes later due to a lung malformation, a common birth defect in cloned ungulates (Rhind et al., 2003).

As mentioned, many advocates of cloning extinct species often focus on the technological advancement, what Sandler calls de-extinction's "technological wizardry" (2013). This was reflected in an interview with Juan, another cloning scientist: "we were doing something new. No one had done it before. With cloning technology, we achieved the birth of an extinct animal. That was the first step." I asked Juan what would have happened if the clone had survived. "I think," he responded, "that it would become an animal of … [hesitates] … maybe simply an *experimental animal* or something like that." If the bucardo cloning *had* been successful, scientists in Zaragoza would only have found themselves in the same position as 1999, with one female left. Any realistic attempt of ecological restoration with cloned bucardo would have to rely on hybridisation with other subspecies at some point; the genetic material from one individual could not be used to recreate a population on its own. Juan hypothesised: "we would have had to try to cross-breed in captivity, but you never know what could be possible, with new tools like CRISPR developing … and those [genome editing] technologies that come in the future, well, we don't know, but maybe we could introduce some genetic diversity." This highlights a fundamental flaw in cloning as a means of preserving "pure" bucardo – not only are "bucardo" clones born with the mitochondrial DNA of domestic goats, but the hypothetical clone would also be subjected to further hybridisation. This begs the question, could such an animal ever be considered an authentic bucardo? As the work of Carrie Friese (2010) has shown, classifying chimeras is far from straightforward.

Felipe was adamant that cloning scientists were doing "everything they could" to "return bucardo to Ordesa." Many environmental activists against the cloning project rejected these claims of cloning scientists, arguing that interventions in Pyrenean ecology could not be made from the outsider's perspective of the laboratory. One activist, Núria, said that the scientists who cloned a bucardo "were thinking about an experiment, not about ecology, not about the Pyrenees." Gabriel, another activist, was insistent that resources and public attention directed to cloning inherently "distracted from conservation projects" and "prevented us from helping Pyrenean ecology … the media didn't help, it [the cloning] was too new, too interesting."

Ecologistas en Acción [Ecologists in Action], a confederation of 300 grassroots environmentalist groups across Spain,[6] publicly campaigned against the cloning project by citing a number of "technical, scientific, and social" reasons for their opposition. In addition to claims that the project lacked any genuine ecological plan for reintroducing hypothetical lab animals, unfit for restoration due to poor genetic health, they note that: "a species is also defined by its **phenotype**: in addition to genetic inheritance its environmental context (learned behaviours, access to food, adaptation to the surroundings) is what assured the bucardo's identity" (*Ecologistas en Acción*, 5 May 2010). Interviews with members of *Ecologistas en Acción* often reflected this sentiment – strong critiques of the genotypically-centric vision of *what a bucardo is* propagated by cloning scientists. Others raised ethical concerns about the potentialities of such technologies or public imaginaries to distract from *in situ* conservation,

which the organisation claims is a "misleading idea that one may handle species in captivity, or their genetic material in laboratories, to restore them later, enabling the creation of infrastructures that influence their disappearance" (*Ecologistas en Acción*, 5 May 2010, n.p.).

Throughout the last few decades of the bucardo's life, the Pyrenees were haunted by the bucardo's extinction, of an inevitable "future-to-come" (Derrida, 1993). But there was a haunting of another sort, the promise of biotechnological salvation, particularly following the successful cloning of Dolly the Sheep in 1996 and all the "hype" that surrounded it (Franklin, 2007). However, the failure of the cloning project haunted, and continues to haunt, the Pyrenees. For the scientists in the Zaragoza laboratory, the clone's death was a heart-breaking moment. Juan told me that there were many tears. Were they upset at the death of an experimental animal? At the revisiting of the bucardo's extinction? At the muddled liminalities of de/extinction? Environmental activists thought not, and cynically suggested that scientists were upset about a failed experiment. Gabriel thought that with the death of the clone, the cloning scientists "lost their chance to become famous and to put Aragón on the map." Funding was cut for the cloning project, which government officials in Madrid told me was due to the importance of other, feasible, restoration solutions. Mateo, one of the Madrid officials, remarked that there was an "inertia in the cloning laboratory" to consider anything beyond the genotypically-centric solution.

In April 2013, *National Geographic* published a special issue on the revival of extinct species and held a series of high-profile public conferences on the theme. The opening lines of the editorial placed the bucardo at the forefront of this agenda: "On July 30, 2003, a team of Spanish and French scientists reversed time. They brought an animal back from extinction, if only to watch it become extinct again" (Zimmer, 2013, p. 28). Capacities of cloning to *reverse time*, however tongue-in-cheek, encapsulate the uncanny and spectral temporalities of de/extinction. Ten years after the failed cloning attempt, the bucardo was back in the public eye, and considerable hype was growing about its speculative return. Cloning scientists secured further funding – ironically, from the hunting federation of Aragón – and attempted further cloning attempts in 2014 (Kupferschmidt, 2014). Speculation around de/extinction resulted in significant opposition from ecologists in the Pyrenees (García-González & Margalida, 2014), and *Ecologistas en Acción* held a protest in Ordesa, calling for "more conservation, less cloning".[7]

The most effective opposition to the cloning project, though, did not come from human activists. Rather, this came in the form of Iberian ibex themselves, translocated to the French Pyrenees just months after the second cloning project failed. Juan saw the successful introduction of Iberian ibex to the French Pyrenees as a halt to "the possibilities for any future bucardo cloning programme." Those working on cloning were firmly opposed to any introductions of a non-endemic ibex, convinced that they wouldn't be able to survive and reproduce, as Felipe explained "the conditions are tough – so tough – we thought that any non-bucardo ibex would die in winter." Ecologists in the French Pyrenees, conversely, had been holding on to a glimmer of hope: the survival of an introduced male originally intended to hybridise with Celia. When nine ibex were released in the Vallée de Cauterets in July 2014, the bucardo's absence took on new meaning.

4 | RESTORATION AND DEFYING THE EMPTINESS

The bucardo continues to haunt the Pyrenees. Its absence has recently been reimagined through a flagship ecological restoration project, marketed by the *Parc National des Pyrénées* as "the return of the Iberian ibex to the Pyrenees."[8] What might it mean, then, for ibex to *return*? These animals are not bucardo – rather, they are ecological and cultural proxies. The ways in which they are understood to *belong* in the Pyrenees is not straightforward; shaped by myriad issues linked to tourism, hunting, and nationalism, among others. On 10 July 2014, nine ibex from the Sierra de Guadamarra, near Madrid, were released in top secret in the Vallée de Cauterets – not far from Ordesa on the north-facing slopes of the Pyrenees. Subsequent releases have reinforced the population to a self-sustaining number. In a relatively short time, introduced ibex are beginning to establish themselves as part of the Pyrenean landscape. Juan told me that this introduction "changed everything," noting that "it's taken away the strength of any project wanting to return bucardo to the Pyrenees because now, basically, there's an ibex which is adapting very well." Introduced ibex haunt the ecosystem, embodying the bucardo's spectres, *revenants* hinting at ecological pasts which *arrive* in the present.

In 1982, Jean-Paul Crampe first set out a proposal to release Iberian ibex in the French Pyrenees, yet this wasn't supported officially until the end of the decade by the national park (Crampe, 1990, 1991, 2020). Nonetheless there was still no substantial mobilisation of a political movement to start a translocation project while the bucardo remained in Ordesa, as Mateo told me in Madrid, "the bucardo was only found in the Pyrenees, so trying to conserve it had to be the focus, before we could start thinking about other ibex." Ecologists and government officials on both sides of the Pyrenees retained a certain pragmatism and cautious pessimism to the bucardo recuperation plan in the 1990s. Mateo told me that when "saving the bucardo seemed unlikely," there was an informal contract between France and Spain: "it was a tacit agreement – unwritten – that they'd wait for the result of the

[LIFE] conservation programme before making any move to reintroduce other ibex, but there was a commitment that if it didn't work out with the bucardo there would be [transnational] collaboration [for an ibex introduction].” This clandestine agreement came from a few key figures in Madrid and did not reflect the broader geopolitical narrative at the time; one through which ibex were being framed as a resource of national sovereignty. There was, and still is, a deep sense of patrimony over Iberian ibex from many culturally and politically significant actors in Spain, as recounted by Pedro, a conservationist working in Aragón, “the opposition was essentially for the exclusivity of a resource, that the ibex would only be Spanish.”

There are numerous factors which complicate the story. Raphaël, an ecologist based near Lourdes, told me that: “if you want to narrate it, to be honest, you can't escape politics. Politics, economics, but also the Spanish peculiarity of big-game hunting, and the rich conservative hunters who saw – and still see – ibex like their own to do what they want with.” Spanish hunters and certain conservation actors were deeply opposed to the French introduction due to fears of losing territorial (and biopolitical) sovereignty over Iberian ibex as a hunting resource. Raphaël even told me that “the old king of Spain [Juan Carlos I], famously a dedicated hunter, was against the French ever being able to hunt ibex in France;” rather, “he thought they should have to come to Spain.” Gaël, a senior ecologist in the French Pyrenees, explained that the political influence of hunters in Spain is unavoidably linked to “the power of the right, the ultra-rich conservative landowners, that have their ways politically.” Multiple ecologists told me about their concerns about opponents to ibex translocation. They talked of planned roadblocks, sabotage, and furtive hunting in retaliation. Spanish hunters were strictly opposed to the idea that Iberian ibex could ever be hunted (speculatively, one day) beyond the Iberian Peninsula.

Permissions to hunt ibex in Spain are worth multiple millions to local governments, and hunting tourism is incredibly popular. Hunters in Aragón often spoke with pride about the exclusivity of Iberian ibex hunting in Spain – and there were genuine fears about this being lost – despite the illegality of ibex hunting in France. There is a plethora of tourism companies geared towards wealthy hunters from around the world which play up to this “unique” opportunity to hunt Iberian ibex. Whilst conducting ethnographic work at a hunting fair in Aragón, for example, many hunters told me with pride that Donald Trump Jr was in Spain at the time pursuing ibex trophies. Bucardo were historically favoured over Iberian ibex as trophies for two reasons: their horns were more spectacular, and they were considerably rarer, spectral (Searle, 2021). Andrea, an environmental activist, told me that the financial backing from the hunting federation of Aragón “says it all; hunters just wanted the big horns back.” The hunters in Spain whom I interviewed seemed to generally support cloning, despite mostly acknowledging the improbability of ever being able to hunt bucardo – or introduced ibex in the Pyrenees for that matter. Mateo, the conservation official in Madrid, quipped that “by the time the introduced ibex population is viable to hunt, there'll probably be no hunters left. People's attitudes are changing in Spain and France.”

In France, there was a sentiment that once ibex *were back*, there would be no removing them; ibex geographies and topologies would themselves become a conservation actor (Jepson et al., 2011; Lorimer et al., 2019). Due to political issues – and past disruptions from protestors – the first release was conducted “in the greatest secrecy” according to Gaël. Once they were there, free, the ibex populations began to adapt to the north and defy the widely held belief that Iberian ibex could only survive in warmer, southern climates. For the second release – in the public eye – this fear was gone. Even French ecologists very active in the Pyrenees were shocked that Spain had relented in allowing ibex over the border, as retold by Gaël, “I had many colleagues saying ‘shit! How did they do that?!’” The memoirs of national park chief ecologist Jean-Paul Crampe, *Le Bouquetin aux Pyrénées* [Ibex in the Pyrenees] (2020), detail the decades of work that cumulated in the eventual release. Gaël noted that “it was a lifetime's work” to overcome the geo- and bio-political obstacles enacted by the hunting and tourism industries.

I was keen to know where the bucardo's absence fitted into the landscape in the presence of introduced ibex. David, an ecologist in Ordesa who had fiercely opposed the cloning project, was adamant that “memory fades,” therefore Iberian ibex can “remind people” of the bucardo. The bucardo's extinction haunts the French Pyrenees. Its absence had served as the rationale for the translocation of other ibex to its habitat, and the presence of Iberian ibex in the Pyrenees draws attention to, and heightens sensibilities of, the bucardo's absence. Dolly Jørgensen (2019) argues that ecological restoration is a process involving mourning, loss, and hope. The report published by the *Parc National des Pyrénées* in 2012 detailing their aspirations for the translocation of ibex is filled with affective language among ecological, social, and economic rationales. The inside cover explains that the project is “driven by the hope of all mountain lovers to finally see the Pyrenean peaks, cliffs, and ravines adorned again with elegant and spectacular ibex silhouettes playing with – defying – the emptiness [*se jouant du vide*]” (Crampe et al., 2012, p. 6).[9] As mentioned, support for the project was – and is – driven by a firm belief that something was missing in the bucardo's wake, and therefore that something *belongs* (Jørgensen, 2019; O’Gorman, 2014). Feelings that the ibex belong continue to shape the spectral ecologies of the Pyrenees.

Speaking to certain groups of people on both sides of the Pyrenees sheds light on the discursive function of *to belong*: nothing inherently belongs, rather, belonging is constructed and brought into being through a range of ontological and epistemological frameworks. Exploring discourses of belonging exposes often-uncomfortable politics, where these worldviews may collide

violently. For Raphaël, introduced ibex already belonged in the Pyrenees: "it's as if the ibex is an emergent property of the rock, isn't it? As if a rock flower had bloomed into a mountain goat." Each new generation of ibex is adapting to the Pyrenean winters better, growing and thriving like flowers from the rock. In 2020, at least 70 kids were born in the French Pyrenees, and the total population now exceeds 400. Even Felipe, in the cloning laboratory, commended the project's success: "that is the next chapter of the bucardo's history, it's happening there, in France." Introduced ibex are strategically translocated to expand the population's range across the whole Pyrenean massif, in an effort that subpopulations will hybridise and spread out over an expansive territory. They have already moved into Spain. David was optimistic that "before long they'll be back in Ordesa. It's not genetically a bucardo, but it's close."

5 | PHENOTYPIC DE/EXTINCTION

As oblivious to the geopolitical designation between Spain and France, these nonhuman protagonists are challenging to the border placed around extant and extinct. Politics of belonging and the construction of authenticity in de/extinction are founded on the degree to which the new animal is considered a faithful replica of the absent. In this section I explore the changing degrees of difference and resemblance between Iberian ibex and bucardo.

What sets an Iberian ibex and bucardo apart? Taxonomic classifications of *Capra pyrenaica* and its disputed subspecies have historically been founded on – and institutionally remain – morphology as the producing factor of difference (Granados et al., 2001; Pérez et al., 2002). Concerning the resemblance of Iberian ibex (*Capra pyrenaica victoriae*) and bucardo (*Capra pyrenaica pyrenaica*), Claudio, a resident of Torla, told me that: "side by side, by looks only, for most people it would be hard to tell the difference, it's like you have to search for the differences." Antoine, a park ranger working closely with the ibex project, felt that differences were fabricated for political ends, cynically noting that "people who want differences in ibex can invent them however they like. There's no rulebook so it's easy." It is true that every ecologist I spoke to in France considered the bucardo and introduced ibex indistinguishable in terms of their ecological function. But *belonging*, the ethical and aesthetical frameworks that shape the extent to which something *deserves to be* in a given space and time, is a cultural category. For Dolly Jørgensen, "it is something determined by humans as a judgement on the appropriateness (or inappropriateness) of a species in a place" (2019, p. 9).

Critics of the cloning project often note that *phenotypes* – interactions between genes and the broader environment – are more important to organisms than the genetic code they inherit. Scientists cloned the bucardo because they deeply felt it belonged in the Pyrenees. In striving for this, though, they felt other ibex did not belong there. Juan told me that "none of us thought another ibex would be able to survive in the Pyrenees, truly." Roser, an environmental activist, dismissed this as a simplistic justification for the cloning project: "that's how they justified what they're doing or were doing," which was, for Roser, a means of achieving "fame and success" for "Aragón and Spain" as opposed to France. Iberian ibex differ from the bucardo – morphologically, culturally, politically – productive of subjectivities, partialities, and différance (Derrida, 1981). Ibex in the Pyrenees resemble the bucardo, and present perceptions of these ecological proxies merge with the absences of extinction in spectral ecologies. As Derrida notes in *Spectres of Marx*, the apparitional ghost and that which it represents are lost in each other, what he calls "the striking difference" between "two modalities or temporalities in the conjuration of the dead. … It must be noted that they resemble each other," he writes, and "they contaminate each other sometimes in such a troubling manner" (1993, p. 181). Released ibex in the Pyrenees resemble the bucardo (Figure 3), ecologically akin, unsettling the taxonomic boundaries drawn around these animals.

The taxonomic debate surrounding bucardo and Iberian ibex is deeply polemical, and partial. Most who support restoration via translocation adhere to its official classification as a subspecies – or even as a subpopulation – whereas those who support cloning regularly found the importance of their argument based on the idea that official taxonomic classification overlooks the bucardo's endemism. Recent phylogenetic analysis has demonstrated that bucardo constitute an evolutionary significant unit, suggesting three groups of wild ibex in Europe that diverged about 50,000 years ago: Alpine ibex, bucardo, and Iberian ibex (Ureña et al., 2018). Taxonomic distinctions between different ibex continue to enlist the animals into a particular ideological frame, one redefining the politics of belonging and an ethics of what *should be*. Articulations of difference between ibex are often founded on the genome itself as the principal determining factor in the suitability of proxies. Metrics of biological diversity focusing solely on the genotype, however, tend to mute or downplay the importance of phenotypic expression. A shift away from the genome as the central focus of de/extinction, to one that considers the expression of variability at the population scale, elucidates very different understandings of biotic loss and recovery.

FIGURE 3 Comparative image of (a) bucardo and (b) Iberian ibex in the Pyrenees
Source: The photograph of the bucardo was taken by Bernard Clos in Ordesa, Spain, in 1981 [© B. Clos – Parc National des Pyrénées]. The photo of Iberian ibex was taken by Jean-Paul Crampe in the Parc National des Pyrénées, France, in 2019

When conservation concern for the bucardo emerged around the turn of the 20th century, there was considerable debate concerning its classification relative to the Iberian and Alpine ibex (Cabrera, 1911, 1914; Ménégaux, 1903; Sclater, 1886). In 1911 Ángel Cabrera published his theory on ibex taxonomy in the *Proceedings of the Zoological Society of London*, which has remained the standard classification system used to this day. Cabrera's classifications are dependent on two factors: morphology (horn size, body size, and coat colour) and geographical distribution. Introduced ibex are in the footsteps of bucardo, in the Pyrenees, and therefore bear a certain semblance in this classification system. Morphology, therefore, remains the key differentiating factor in the formation of divergences in ibex, historically the epistemological foundation for boundary-making. Cabrera writes that "the size of the horns is decidedly larger in the Pyrenean ibex" (1911, p. 973). As Iberian ibex adapt to tougher conditions in the Pyrenees, without the selection pressures of hunting for large-horned individuals and its evolutionary consequences (Pigeon et al., 2016), their morphologies are shifting.

Antoine reflected on this in an interview. "The Pyrenees are changing how the ibex look … they have to be bigger – you know, fatter, stronger, bigger horns – in order to survive the tougher conditions here than they get in parts of Spain." Bigger ibex with bigger horns – that which set the bucardo apart from the other ibex centuries ago when taxonomic boundaries were drawn – are showing glimpses of return. Mateo echoed this sentiment:

> After just one generation you see the difference, but this is also due to the stress of translocation and the rest. They lose a year's horn growth from it. But look at the kids being born there now, they've got the whole Pyrenees to themselves, without population pressure and without hunting. Who's to say after a few more generations they'll start to look more and more like bucardo?

Speculatively the ibex currently in the Pyrenees, free from hunting pressures, might even look *more* like bucardo – bigger with bigger horns – than those which remained in the Ordesa bottlenecked population by the turn of the 20th century. Mateo made this

point in Madrid, also noting that "Ordesa was a suboptimal habitat, this is just where bucardo were least visible to hunters, so where they held on." There are, realistically, too many uncertainties regarding the futures of this population. But facing these speculative and uncertain outcomes, as brilliantly summarised by Antoine, "we can be sure that they won't be the same as in Madrid … they will adapt over time to become/to bring about [*pour devenir*] the Pyrenean ibex." Raphaël found this the most exciting part of the de/extinction story, calling it "an interesting twist in the natural history of the Pyrenees" that no one "will be around to see how it ends up." A shift in focus to traits, such as these altered morphologies, engenders considerations of de/extinction focused on the "resurrection of ecological interaction" (Despret & Chrulew, 2020, p. 188).

Broadening the ontological scope of de/extinction to include the phenotypic shifts associated with translocation takes focus away from visions of biotic recovery centred wholly on genotypes or the proposed technologies of resurrection.[10] The agencies of Iberian ibex in the footsteps of ghosts – and their genetic makeup – call into question claims that cloning can function as a restorative technology. If the overarching goal is the restoration of flourishing ecologies shaped by multispecies interactions and communities, then justifications of cloning are invalidated by phenotypic de/extinction. Iberian ibex in the Pyrenees are not bucardo, but they resemble them, in the same geographical location; chimeras which don't easily fit into the static borders drawn around these nonhumans. As discussed in section 3, hypothetically cloned bucardo would also be hybrid animals. Future plans for the ibex translocation project seek to further attain hybridity by sourcing ibex from mountain ranges throughout the Iberian Peninsula (Manceau et al., 1999), which "would enhance their adaptive potential" (Angelone-Alasaad et al., 2017, p. 10). The open-ended nature of this population suggests that it is likely to be completely distinct from both bucardo and Iberian ibex; rather, a new population of ibex in the Pyrenees.

6 | SPECTRAL ECOLOGIES

Different groups of people have very contrasting understandings of the bucardo's extinction, cloning, and the release of related animals as ecological proxies. So, what does this show? The figure of the ghost brings to the fore multiple pasts and futures, human and nonhuman, materialising and affecting bodies in *spectral ecologies*. The ghosts of the bucardo persist in the Pyrenees, and shape the more-than-human worlds which come in the wake of its extinction. Ecosystems are haunted by extinctions – many of which are unseen, unknown, or uncharismatic (Lorimer, 2007). There is a clear bias in my account that attends to the ghosts of an emblematic and spectacular animal (Searle, 2021); moving forward, geographers should seek to elucidate scarcer more-than-human spectres.

Both cloning and restoration practice rework the bucardo's absence in fascinating ways, and empirically problematise the changing meanings of extinction in the presence of novel technologies. Facilitated through a skin biopsy, the material disconnection between body and cell opened up the bucardo to a plethora of new meanings – the first animal to be outlasted by its cryopreserved cells; the first extinct animal to be cloned; the first animal to go extinct twice. The degrees to which introduced ibex were felt to belong in the Pyrenees were shaped by a plethora of economic and political issues, but in the end, the mobilities of the animals themselves are questioning the theoretical validity of any such discursive distinction. Iberian ibex released in the Pyrenees are starting to look more and more like the bucardo each generation – uncanny and unsettling resemblances to the ghosts of extinction. This raises considerable questions regarding the role of cloning as a means of reuniting the Pyrenees and its endemic ibex – even if the bucardo clone had survived, would it be an authentic bucardo if confined to a laboratory? Could an ecological proxy that visually resembles the absent biota ever be classified as an authentic replacement?

Where to next? It is clear that the bucardo's story is complex and multifaceted and does not afford sweeping generalisations, and it is unknown if, with introduced ibex in the footsteps of ghosts, the bucardo will fade away. Following the mobilities and geographies of introduced ibex themselves calls into question the groundings for cloning in conservation. But it highlights that, in an era of loss and absence, past ecologies will persist and unsettle. It is a reminder that ecologies are haunted by lost futures and pasts, and a call to think through the ethical and aesthetic questions posed by disjointed geographies. Perhaps we should conjure new modes of ecological thought and means of considering more-than-human geographies, which account for these ghosts: learning about conservation and multispecies care is to learn from the extinct. The presence of absent biota is always carried by the living, yet more-than-human spectres are especially palpable in times of mass extinction. Spectral ecologies are everywhere. Rather than seeking technological fixes to rework the absences of lost biota, an approach that focuses on the genome itself, restoration should embrace the flourishing potentials of ecological relationships at the landscape scale with an emphasis on phenotypes. Such an approach creates more opportunities for living, and dying, in more-than-human worlds.

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DATA AVAILABILITY STATEMENT

For reasons of participant anonymity, data are not shared.

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ENDNOTES

[1] "Our final goal will be to repopulate the Pyrenees … with these giant ibex who were very well adapted to high mountains and extremely cold winters," notes Alberto Fernández-Arias in a special TEDxDeExtinction talk, called *The First De-Extinction* (https://reviverestore.org/events/tedxdeextinction/the-first-de-extinction/) accessed June 2021.

[2] I chose the term "spectral ecologies" through its reference to the established field of "spectral geographies" and Derrida's *Spectres de Marx* (1993). On a web search, I found that the term "spectral ecologies" has been used previously for a 2017 cinematic exhibition in Australia by Bridget Crone, Sam Nightingale, and Polly Stanton (http://www.thecinemasproject.com.au/spectral-ecologies/) accessed June 2021.

[3] I am grateful to an anonymous reviewer for this observation.

[4] In spoken French, hauntology and ontology sound the same [*hantologie* and *ontologie*], hinting at the prominence of haunting in all ontology (Derrida, 1993).

[5] This EU-funded "LIFE" project "Conservation of threatened vertebrates in the Pyrenees" (LIFE95-NAT/E/001160) was a transnational agreement between the Spanish and French states, in addition to regional governments of Navarra, Aragón, and Catalunya. Funding was worth just over one million euros and lasted from 1994 to 1998.

[6] On the *Ecologistas en Acción* homepage, the organisation defines itself as a confederation of more than 300 local groups based across cities and towns throughout the Spanish state.

[7] The organisation's press release detailing this protest can be found here: https://www.ecologistasenaccion.org/29210/piden-paralizar-la-clonacion-del-bucardo/) accessed June 2021.

[8] « *Le retour du bouquetin dans les Pyrénées* » is coherent with the project's branding, which is updated regularly (https://www.bouquetin-pyrenees.fr/) accessed June 2021.

[9] The multifaceted evocations of *se jouant de vide* are lost in translation. It could also be understood as "making light of" or "defying" the emptiness in the Pyrenees.

[10] In "broadening the ontological scope," I take influence from the recent work of Maan Barua, which offers a "wider ontology" of infrastructure beyond anthropocentricism to generate "new analytics and critical openings for the politics of governing human and non-human life" (2021, p. 1).

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